IN THE UNITED STATES PATENT AND TRADEMARK OFFICE BEFORE THE

BOARD OF PATENT APPEALS AND INTERFERENCES

Applicant:	Willem Roux
Title:	Method and System for Distinguishing Effects Due to Bifurcation from Effects Due to Design Variable Changes in Finite Element Analysis
Serial No.:	10/700,217
Filing Date:	11/03/2003
Examiner:	Andre Pierre Louis
Group Art Unit:	2123
Docket No:	LSTC-002
Customer No:	**37804**

January 25, 2008

Mail Stop: Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
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APPEAL BRIEF

This appeal brief is submitted in response to the final rejection dated October 12, 2007 and the Notice of Appeal filed on November 26, 2007.

No fee is required for filing this appeal brief, if it is determined that a fee is due in connection with this paper, the Commissioner is hereby authorized to charge payment of any fees associated with this communication or to credit any overpayment, to Deposit Account No. 553308.

I. REAL PARTY IN INTEREST

The real party in interest is the assignee, Livermore Software Technology Corporation, 7374 Las Positas Road, Livermore, California.

II. RELATED APPEALS AND INTERFERENCES

Neither Appellant nor Appellant's Agent is aware of any related appeals, interferences or judicial proceedings.

III. STATUS OF CLAIMS

Claims 2, 8 and 14 have been canceled. Claims 1, 3-7 and 9-13 are pending in the application and on appeal. A notice of appeal was filed on November 26, 2007. The status of the claims in final Office Action dated October 12, 2007 is as follows: Claims 1, 3-7 and 9-13 are rejected under 35 U.S.C. §103(a) for being unpatentable over Venkataraman (a Ph.D. dissertation entitled: "Modeling, Analyzing, and Optimization of Cylindrical Stiffened Panels for Reusable Launch Vehicle Structures" at University of Florida, 1999, hereinafter "Venkataraman"), in view of Tyron, III et al. (U. S. Patent No. 7,006,947, hereinafter "Tyron").

Claims 1 and 3-6 stand or fall together
Claims 7 and 9-12 stand or fall together
Claim 13 is an independent claim without any dependent claims.

IV. STATUS OF AMENDMENTS

On November 3, 2003, claims 1-12 were initially filed. Claims 1 and 7 are independent claims.

On January 4, 2007, claims 1 and 7-12 were amended, and claims 13-14 were added in a "Response (A)" to a first non-final Office Action dated October 10, 2006. Claims 1, 7 and 13 are independent claims

On April 25, 2007, claims 1, 6, 7, 12 and 13 were amended, and claims 2, 8 and 14 were cancelled in a "Response (B)" with a RCE request to a first final Office Action dated March 23, 2007.

On August 7, 2007, no claims were amended in a "Response (C)" to a second non-final Office Action dated May 15, 2007.

No response was filed to the second final Office Action dated October 12, 2007. (This appeal brief is for an appeal to the rejection made in the October 12, 2007 Office Action.)

V. SUMMARY OF CLAIMED SUBJECT MATTER

The claimed subject matter comprises methods and systems for distinguish effects due to bifurcation from effects due to design variable changes in a structural design study (e.g., a finite element analysis). In a structural design study, usually a set of experiments with different design variables values are analyzed with the underlying FEA software. After the set of FEA results that correspond to the experiments are obtained, engineers will then construct a metamodel such as response surface based on a least squares fitting technique using these FEA results. The metamodel can be based on any component of structural responses (e.g., nodal displacement, acceleration time history, etc.). From the constructed metamodel, the responses of all other combination of design variables can be predicted.

Because the metamodel predicts the average expected responses, the FEA results are in general scattered but clustered in the vicinity of the predicted results of the metamodel. However, when the bifurcation exists in FEA responses, the metamodel may not be able to predict those responses since there are more than one valid mode. According to one aspect of the present invention, the FEA results of the design experiments that are not predicted by the metamodel are classified as outliers. Outliers are the likely candidates that may have bifurcation (e.g., buckling) in the structural response.

This is a huge improvement over all of the old techniques of guessing which experiment may have bifurcation. For example, one technique referred as Monte Carlo simulation. A randomly selected set of design experiments are used. The corresponding FEA results are a cluster of cloud centered about a mean position. There is no way to distinguish which case in the cloud has a bifurcation.

To further verify the effects due to bifurcation, the outliers and the corresponding standard deviations are computed for every node or element in the FEA model and the standard deviation of the outliers are plotted on a finite element analysis mesh model. The region having a substantially higher standard deviation comparing to the overall structure usually indicates bifurcation. These unstable regions can also be identified using a different measure of the outliers such as the range — the difference between the maximum and minimum value. An engineer can then compare the FEA response of two extreme experiments such as the maximum and minimum outlier to verify the occurrence of the bifurcation.

In accordance with 37 C.F.R. § 41.37 (c)(1)(v) "A concise explanation of the subject matter define in each of the independent claims involved in the appeal, which must refer to the specification by page and line number, and to the drawing, if any, by reference characters.", all page and line numbers and drawings, as used in the Specification as originally filed, are in italic and inserted directly in the independent claims below:

> 1. A method for distinguishing effects due to bifurcation from effects due to design variable changes used in a finite element analysis (FEA) for designing a structural product by a user of the FEA, the method comprising:
>
> obtaining in a computing device a plurality of finite element analysis responses for a set of design experiments, wherein each of the set of design experiments has a specific combination of design variables

values; *(paragraph [0039] from last line of page 9 to line 4 of page 10, and element 110 of FIG. 1)*

constructing a metamodel from the plurality of finite element analysis responses; *(paragraph [0039] from line 4 of page 10 to line 5 of page 10, and element 120 of FIG. 1,and paragraph [0041] from line 3 of page 11 to line 9 of page 11 and element 410 of FIG. 4)*

selecting a set of outliers from the set of design experiments whose finite element analysis responses are not predicted by the metamodel; *(paragraph [0039] from line 10 of page 10 to line 12 of page 10, and element 130 of FIG. 1, and paragraph [0041] from line 3 of page 11 to line 9 of page 11 and element 420 of FIG. 4)*

identifying high likelihood bifurcation region of a FEA model that represents the structural product by plotting an indicating quantity of the finite element analysis responses; and *(paragraph [0039] from line 11 of page 10 to line 16 of page 10, and element 160 of FIG. 1, and paragraph [0042] from line 13 of page 11 to line 21 of page 11 and elements 510 and 520 of FIG. 5)*

examining the finite element analysis responses of a couple of the outliers to determine whether the effects are due to the bifurcation or due to the design variable changes, wherein the couple of the outliers is maximum and minimum of the set of outliers. *(paragraph [0039] from line 17 of page 10 to line 20 of page 10, and element 170 of FIG. 1, and paragraph [0043] from line 22 of page 11 to line 27 of page 11 and elements 610 and 620 of FIG. 6)*

7. A computer program product including usable medium having computer readable code embodied in the medium for causing an application module to execute on a computer for distinguishing effects due to bifurcation from effects due to design variable changes used in a finite element analysis

(FEA) for designing a structural product by a user of the FEA, the computer program product comprising:

program code for obtaining a plurality of finite element analysis responses for a set of design experiments, wherein each of the set of design experiments has a specific combination of design variables values; *(paragraph [0039] from last line of page 9 to line 4 of page 10, and element 110 of FIG. 1)*

program code for constructing a metamodel from the plurality of finite element analysis responses; *(paragraph [0039] from line 4 of page 10 to line 5 of page 10, and element 120 of FIG. 1,and paragraph [0041] from line 3 of page 11 to line 9 of page 11 and element 410 of FIG. 4)*

program code for selecting a set of outliers from the set of design experiments whose finite element analysis responses are not predicted by the metamodel; *(paragraph [0039] from line 10 of page 10 to line 12 of page 10, and element 130 of FIG. 1, and paragraph [0041] from line 3 of page 11 to line 9 of page 11 and element 420 of FIG. 4)*

program code for identifying high likelihood bifurcation region of a FEA model that represents the structural product by plotting an indicating quantity of the finite element analysis responses; and *(paragraph [0039] from line 11 of page 10 to line 16 of page 10, and element 160 of FIG. 1, and paragraph [0042] from line 13 of page 11 to line 21 of page 11 and elements 510 and 520 of FIG. 5)*

program code for examining the finite element analysis responses of a couple of the outliers to determine whether the effects are due to the bifurcation or due to the design variable changes, wherein the couple of the outliers is maximum and minimum of the set of outliers. *(paragraph [0039] from line 17 of page 10 to line 20 of page 10, and element 170 of FIG. 1, and paragraph [0043] from line 22 of page 11 to line 27 of page 11 and elements 610 and 620 of FIG. 6)*

13. A system for distinguishing effects due to bifurcation from effects due to design variable changes used in a finite element analysis (FEA) for designing a structural product by a user of the FEA, the system comprising:

an I/O interface; *(paragraph [0045] from line 5 of page 12 to line 14 of page 12, and elements 740, 750 and 755 of FIG. 7)*

a communication interface; *(paragraph [0046] from line 17 of page 12 to line 20 of page 12, and element 725 of FIG. 7)*

a secondary memory; *(paragraph [0045] from line 5 of page 12 to line 14 of page 12, and elements 770, 775 and 780 of FIG. 7)*

a main memory for storing computer readable code for an application module; *(paragraph [0045] from line 5 of page 12 to line 14 of page 12, and element 720 of FIG. 7)*

at least one processor *(paragraph [0045] from line 5 of page 12 to line 14 of page 12, and element 710 of FIG. 7)* coupled to the main memory, the secondary memory, the I/O interface, and the communication interface, said at least one processor executing the computer readable code in the main memory to cause the application module to perform operations of:

obtaining a plurality of finite element analysis responses for a set of design experiments, wherein each of the set of design experiments has a specific combination of design variables values; *(paragraph [0039] from last line of page 9 to line 4 of page 10, and element 110 of FIG. 1)*

constructing a metamodel from the plurality of finite element analysis responses; *(paragraph [0039] from line 4 of page 10 to line 5 of page 10, and element 120 of FIG. 1,and paragraph [0041] from line 3 of page 11 to line 9 of page 11 and element 410 of FIG. 4)*

selecting a set of outliers from the set of design experiments whose finite element analysis responses are not predicted by the metamodel; *(paragraph [0039] from line 10 of page 10 to line 12 of page 10, and*

element 130 of FIG. 1, and paragraph [0041] from line 3 of page 11 to line 9 of page 11 and element 420 of FIG. 4)

identifying high likelihood bifurcation region of a FEA model that represents the structural product by plotting an indicating quantity of the finite element analysis responses; and *(paragraph [0039] from line 11 of page 10 to line 16 of page 10, and element 160 of FIG. 1, and paragraph [0042] from line 13 of page 11 to line 21 of page 11 and elements 510 and 520 of FIG. 5)*

examining the finite element analysis responses of a couple of the outliers to determine whether the effects are due to the bifurcation or due to the design variable changes, wherein the couple of the outliers is maximum and minimum of the set of outliers. *(paragraph [0039] from line 17 of page 10 to line 20 of page 10, and element 170 of FIG. 1, and paragraph [0043] from line 22 of page 11 to line 27 of page 11 and elements 610 and 620 of FIG. 6)*

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

The grounds of rejection which Appellant believes to be most pertinent to the present appeal include whether claims 1, 7 and 13 were properly rejected under 35 U.S.C. § 103(a) as being unpatentable over Venkataraman in view of Tyron.

VII. ARGUMENTS

<u>Examiner erred in rejections of claims 1, 7 and 13 as obvious over Venkataraman in view of Tyron</u>

Claim 1 recites:

constructing a metamodel from the plurality of finite element analysis responses;

selecting a set of outliers from the set of design experiments whose finite element analysis responses are not predicted by the metamodel;

identifying high likelihood bifurcation region of a FEA model that represents the structural product by plotting an indicating quantity of the finite element analysis responses;

examining the finite element analysis responses of a couple of the outliers to determine whether the effects are due to the bifurcation or due to the design variable changes, wherein the couple of the outliers is maximum and minimum of the set of outliers.(*Emphasis added*)

The Examiner admitted in the October 12, 2007 Office Action (hereinafter "Office Action") that "[a]lthough Venkataraman does not specifically teach the exact term high likelihood [bifurcation region] of a FEA [model that represents the structural product by plotting an indicating quantity of the finite element analysis responses]" (*Emphasis added*). The Examiner then relied on Tyron and argued in the Office Action that "[n]evertheless, Tyron, III et al. substantially teaches constructing a metamodel in which [one of the] appropriate probabilistic techniques is selected and identif[ied] for examining the finite [element analysis] response of a [meta]model to determine effects/failure, such as buckling/bifurcation in a FEA" is found in Tyron: FIGS. 2(a)-(d), col. 5 line 36 – col. 6 line 45 and figure 5. See page 4 lines 9-16 of the Office Action.

However, the descriptions of Tyron col. 5 lines 39-43 state that "in FIG. 2(a) engineering analysis step 12 begins by identifying failure mechanisms at step 40 through review of warranty and failure data (step 50) and research of literature (step 52) to determine which of the identified failure mechanisms are actual active failure mechanisms (step 54) …". Tyron requires a failure mechanism to be identified right in the beginning of an engineering analysis (e.g., a finite element analysis (FEA)) before constructing a metamodel, not after performing the engineering analysis. In other words, Tyron teaches a failure prediction system merely computing the probability of a known failure mechanism. For example, in Tyron col. 2 lines 38-

39: "Probabilistic analysis can incorporate any number of <u>known</u> failure mechanisms...". (FIG. 2(a) 1.0).

In contrast, the present invention requires no such restriction, therefore, claim 1 recites the limitation of "identifying high likelihood bifurcation region of a FEA model ..". The failure mechanism is unknown at the time of creation of a metamodel in the present invention, thereby it can only be identifying after analyses have been performed.

Based on at least the above reason, Appellant respectfully submits that Tyron does not teach, disclose or suggest the "<u>identifying high likelihood bifurcation region of a FEA model that represents the structural product by plotting an indicating quantity of the finite element analysis responses"</u> step that the Examiner relied upon in the rejection of claim 1.

Additionally, Venkataraman also teaches the requirement of a prior knowledge of the failure mode before constructing a metamodel as evident in Figures 6.2 – 6.8 pages 163-172. Figure 6.2 illustrates two different buckling (i.e., general and local buckling) modes that are calculated by a computer program - PANDA2 (page 163 bottom 4 lines). Further details of buckling modes and models are shown and described in Figure 6.3 and corresponding descriptions thereof. Another computer program, STAGS, is used for calculating ring local buckling as shown in Figure 6.5 (page 166 lines 1-2). Then in page 168, Venkataraman describes that "a correction response surface is fitted using a small number of STAGS analyses to correct PANDA2 estimates of local buckling load factor". A comparison between the PANDA2 only and the PANDA2 with STAGS correction results is shown in Figures 6.7 and 6.8, respectively. Two known buckling modes, general and local, are considered before a metamodel (e.g., a response surface) is constructed in Venkataraman. Appellant submits that the present invention poses no such requirement when constructing a metamodel. Inspection of analysis results to identify bifurcation occurs after the analyses have been performed.

Further, the Examiner asserted that "[Venkataraman teaches] examining the finite element responses of a couple of outliers to determine whether the effects are due to bifurcation or due to the design variable changes, wherein the couple of outliers is maximum and minimum of the set of outliers (pg.170-173, 137)". See Office Action page 4 lines 6-8.

However, Venkataraman teaches that the outliers are used as indicators for determining whether a response surface approximation is correctly or incorrectly selected. For example, in description for Figure 6.7, Venkataraman states that "If the response surface approximation is exact, then all the points lie on the diagonal line [in Figure 6.7]". See Venkataraman page 170 two bottom lines. Therefore, Venkataraman believes that the outliers are due to poor performance of a response surface model not due to other factors such as unknown failure modes. The present invention requires opposite to this statement. When the points do not line on the line for an exact approximation (i.e., outliers), the present invention needs to determine whether there is any unknown failure mechanism (e.g., bifurcation) by examining maximum and minimum outliers. Therefore, Venkataraman does not teach, disclose or suggest the "examining the finite element responses .." step recited in claim 1.

Furthermore, the Examiner made vague assertions in the Office Action that "[a]lthough Venkataraman <u>does not</u> specifically teach the exact term high likelihood [bifurcation region] of a FEA [model], he substantially teaches <u>performing a finite element analysis on a response surface model</u> to identify bifurcation region of a FEA model that represents the structural product and <u>analyses</u> the finite element response of outliers for maximum and minimum" (*Emphasis added*) is found in Venkataraman: sections 6.1 – 6.8. See page 4, lines 9-12 of Office Action.

First, Appellant respectfully submits that the above assertion is confusing. Appellant interprets the statement as follows: (1) Venkataraman does not teach the limitation "<u>identification high likelihood bifurcation region of a FEA model</u> .." recited in

claim 1 and in all other independent claims; (2) Venkataraman teaches performing a finite element analysis on a response surface model to identify bifurcation region of a FEA model that represents the structural product; and (3) Appellant assumes that the Examiner meant Venkataraman teaches "anal[yzing] the finite element response of outliers for maximum and minimum".

Secondly, Appellant believes that the statement "performing a finite element analysis on a response surface model" is incorrect. Those of ordinary skill in the art (e.g., a structural engineer with a Ph.D. degree) would understand that a finite element analysis is performed on a finite element model representing a structure or structural product, not on a response surface model. A response surface model is an approximation formula used for predicting the structural responses or behaviors within a design experiment. Therefore, Appellant submits that the statement (1) is an admission that Venkataraman does not teach all of the limitations in claim 1 and the statement (2) is moot due to incorrectness.

Finally, in section 2143 of the Manual for Patent Examining Procedure (M.P.E.P.), three basic requirements of a *Prima Facie* case of obviousness must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Secondly, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, not in applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).

As to the first requirement, the Examiner asserts in the Office Action that "Venkataraman and Tyron, III et al. are analogous art ... Therefore, it would have been obvious to one ordinary skilled in the art at the time of the applicant's invention to combine the prediction failure system of Tyron, III et al. with the FEA system of Venkataraman because Tyron, III et al. teaches advantage of using the probabilistic

analysis to provide a more accurate predication of failure and a more rational design decisions at reduced cost and time (col. 4 lines 26-37 Tyron)." (*Emphasis added*) See page 4 lines 16-22 of Office Action. Appellant respectfully disagrees with the reason asserted by the Examiner, because the reason does not relate to the admitted missing limitation of "identifying high likelihood bifurcation region of a FEA model that represents the structural product by plotting an indicating quantity of the finite element analysis responses".

As to the second requirement, even if Venkataraman and Tyron were combined, there is no reasonable expectation of success since both references require a prior knowledge of the failure mode or mechanism before a metamodel can be constructed. In contrast, the limitation recited in claim 1 does not pose such requirement.

As to the third requirement, the cited references do not teach all the limitations as pointed out above.

Accordingly, for at least the foregoing reasons, Venkataraman and Tyron, viewed alone or in any motivated combinations, fail to render Appellant's claim 1 obvious. It is respectfully requested that the rejection be reversed.

Independent claims 7 and 13 recite substantially similar limitations. Appellant would like to apply the same arguments for claim 1 to claims 7 and 13. All dependent claims stand or fall with the independent claims. Therefore, the arguments for claim 1 are also applied to all of dependent claims.

VIII. CLAIMS APPENDIX

1. (Previously presented) A method for distinguishing effects due to bifurcation from effects due to design variable changes used in a finite element analysis (FEA) for designing a structural product by a user of the FEA, the method comprising:

obtaining in a computing device a plurality of finite element analysis responses for a set of design experiments, wherein each of the set of design experiments has a specific combination of design variables values;

constructing a metamodel from the plurality of finite element analysis responses;

selecting a set of outliers from the set of design experiments whose finite element analysis responses are not predicted by the metamodel;

identifying high likelihood bifurcation region of a FEA model that represents the structural product by plotting an indicating quantity of the finite element analysis responses; and

examining the finite element analysis responses of a couple of the outliers to determine whether the effects are due to the bifurcation or due to the design variable changes, wherein the couple of the outliers is maximum and minimum of the set of outliers.

2. (Canceled)

3. (Original) The method as recited in claim 1, wherein the metamodel is constructed using least squares fitting technique.

4. (Original) The method as recited in claim 1, wherein the metamodel is based on nodal displacement.

5. (Original) The method as recited in claim 1, wherein the metamodel is based on acceleration history.

6. (Previously presented) The method as recited in claim 1, wherein the indicating quantity is chosen from the group consisting of standard deviation and range.

7. (Previously presented) A computer program product including usable medium having computer readable code embodied in the medium for causing an application

module to execute on a computer for distinguishing effects due to bifurcation from effects due to design variable changes used in a finite element analysis (FEA) for designing a structural product by a user of the FEA, the computer program product comprising:

program code for obtaining a plurality of finite element analysis responses for a set of design experiments, wherein each of the set of design experiments has a specific combination of design variables values;

program code for constructing a metamodel from the plurality of finite element analysis responses;

program code for selecting a set of outliers from the set of design experiments whose finite element analysis responses are not predicted by the metamodel;

program code for identifying high likelihood bifurcation region of a FEA model that represents the structural product by plotting an indicating quantity of the finite element analysis responses; and

program code for examining the finite element analysis responses of a couple of the outliers to determine whether the effects are due to the bifurcation or due to the design variable changes, wherein the couple of the outliers is maximum and minimum of the set of outliers.

8. (Canceled)

9. (Previously presented) The computer program product as recited in claim 7, wherein the metamodel is constructed using least squares fitting technique.

10. (Previously presented) The computer program product as recited in claim 7, wherein the metamodel is based on nodal displacement.

11. (Previously presented) The computer program product as recited in claim 7, wherein the metamodel is based on acceleration history.

12. (Previously presented) The computer program product as recited in claim 7, wherein the indicating quantity is chosen from the group consisting of standard deviation and range.

13. (Previously presented) A system for distinguishing effects due to bifurcation from effects due to design variable changes used in a finite element analysis (FEA) for designing a structural product by a user of the FEA, the system comprising:

an I/O interface;

a communication interface;

a secondary memory;

a main memory for storing computer readable code for an application module;

at least one processor coupled to the main memory, the secondary memory, the I/O interface, and the communication interface, said at least one processor executing the computer readable code in the main memory to cause the application module to perform operations of:

obtaining a plurality of finite element analysis responses for a set of design experiments, wherein each of the set of design experiments has a specific combination of design variables values;

constructing a metamodel from the plurality of finite element analysis responses;

selecting a set of outliers from the set of design experiments whose finite element analysis responses are not predicted by the metamodel;

identifying high likelihood bifurcation region of a FEA model that represents the structural product by plotting an indicating quantity of the finite element analysis responses; and

examining the finite element analysis responses of a couple of the outliers to determine whether the effects are due to the bifurcation or due to the design variable changes, wherein the couple of the outliers is maximum and minimum of the set of outliers.

14. (Canceled)

IX. EVIDENCE APPENDIX

None

X. RELATED PROCEEDINGS APPENDIX

None

XI. SUMMARY

In view of forgoing arguments, Appellant respectfully solicits the Honorable Board to reverse the Examiner's rejections of claims 1, 3-7 and 9-13 under 35 U.S.C. § 103(a).

I hereby certify that this correspondence is being transmitted to the Commissioner for Patents via the Office electronic filing system on the date stated below.

Date: January 25, 2008

Signature: /Roger H. Chu, Reg.# 52745/
Roger H. Chu

Respectfully submitted;

/Roger H. Chu, Reg. # 52745/

Roger H. Chu
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Agent for Appellant